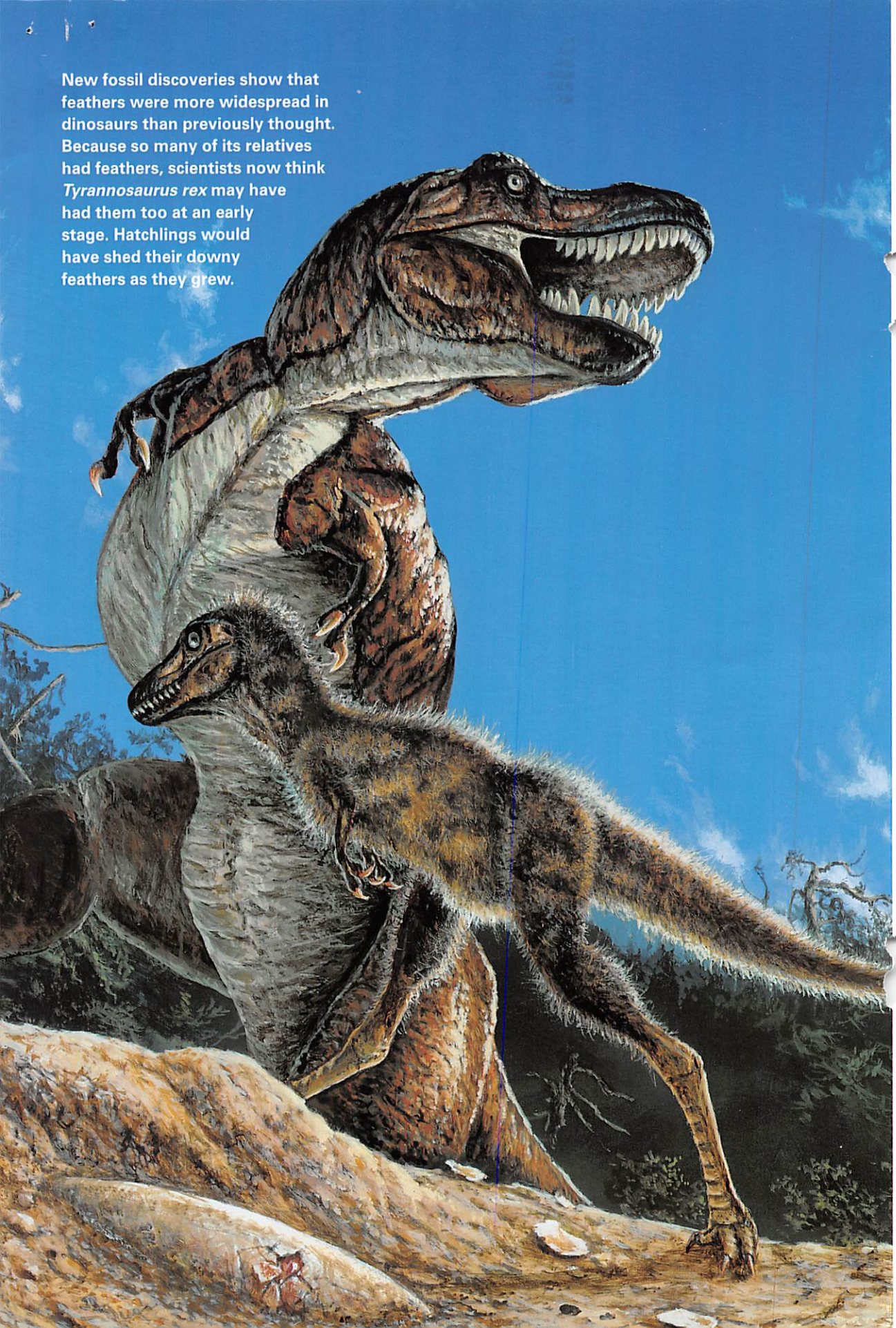
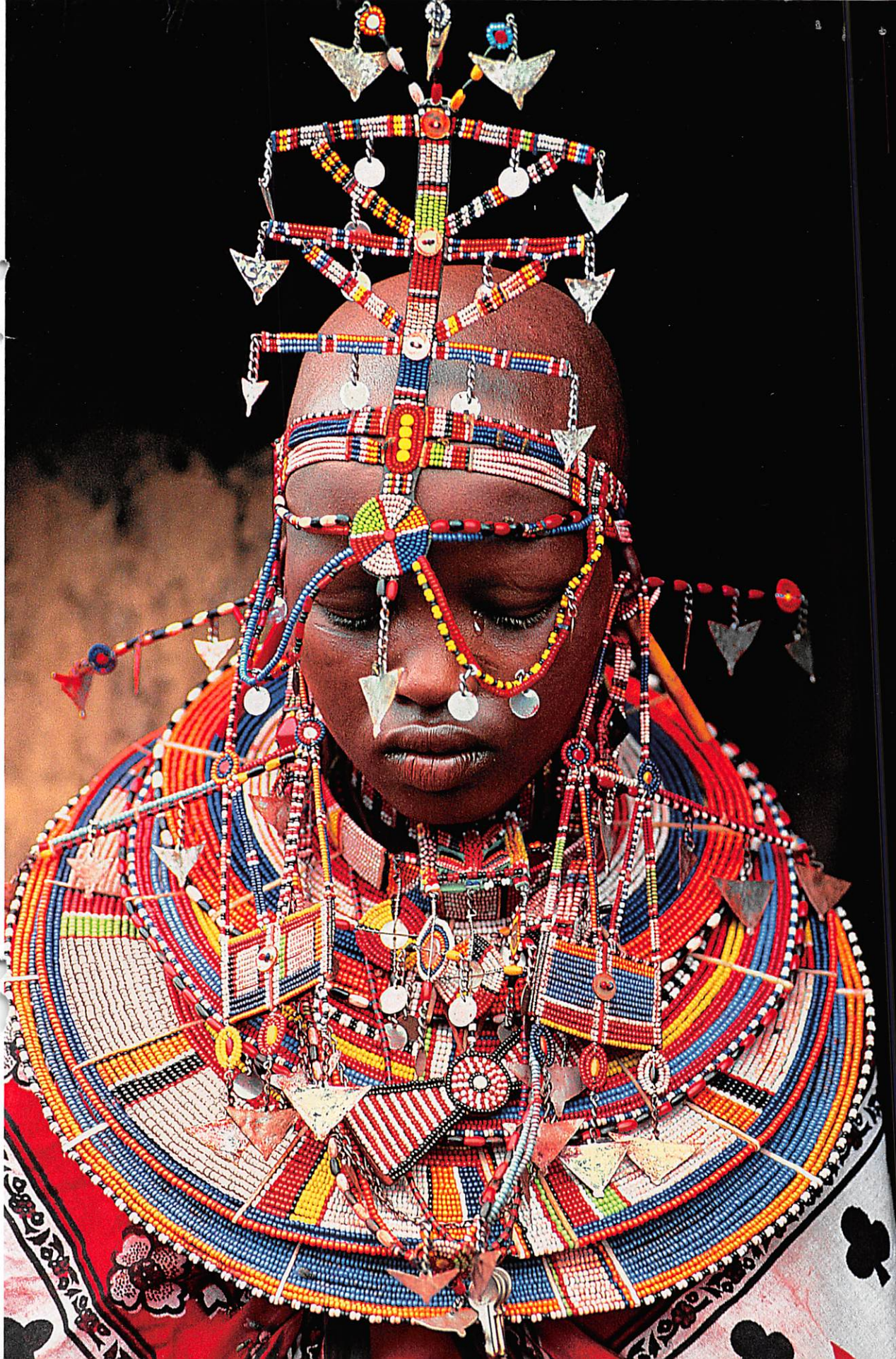


New fossil discoveries show that feathers were more widespread in dinosaurs than previously thought. Because so many of its relatives had feathers, scientists now think *Tyrannosaurus rex* may have had them too at an early stage. Hatchlings would have shed their downy feathers as they grew.



FEATHERS FOR T. REX?

NEW BIRDLIKE FOSSILS ARE MISSING LINKS IN DINOSAUR EVOLUTION

BY CHRISTOPHER P. SLOAN
SENIOR ASSISTANT EDITOR

PHOTOGRAPHS BY
O. LOUIS MAZZATENTA

DINOSAURS will never look the same. The reason: four new dinosaur fossils with stunningly birdlike bones and indications of feathers. Not enough to prove that these dinosaurs ever flew but strong evidence that feathers were widespread among meat-eating dinosaurs—the group that includes *Tyrannosaurus rex.*

Three of the fossils were found recently in Liaoning Province, China, the area that produced fossils of flightless feathered dinosaurs in 1996-97. All four are theropods, or meat-eaters: a dromaeosaur, one of a family of small- to medium-size predators that includes *Jurassic Park*'s "raptors"; an oviraptorosaur from Mongolia with a bird-like tail; a seven-foot-long therizinosaur; and a creature that has the arms of a bird and the tail of a dinosaur.

Twenty years ago when John Ostrom, a

ART BY MICHAEL SKREPNICK

A FLYING DINOSAUR?

MODEL BY STEPHEN CZERKAS

"IT'S A MISSING LINK

between terrestrial dinosaurs and birds that could actually fly."

—STEPHEN CZERKAS

With arms of a primitive bird and the tail of a dinosaur, this creature found in Liaoning Province, China, is a true missing link in the complex chain that connects dinosaurs to birds. Scientists funded by National Geographic studied the animal, named *Archaeoraptor liaoningensis,* under ultraviolet light (above) and used CT scans to view parts of the animal obscured by rock. Preliminary study of the arms suggests that it was a better flier than *Archaeopteryx,* the earliest known bird. Its tail, however, is

strikingly similar to the stiff tails of a family of predatory dinosaurs called dromaeosaurs. This mix of advanced and primitive features is exactly what scientists would expect to find in dinosaurs experimenting with flight. Stephen Czerkas, who led the study of the specimen, reconstructed the new animal (inset), which resembles *Archaeopteryx*. "This fossil is perhaps the best evidence since *Archaeopteryx* that birds did, in fact, evolve from certain types of carnivorous dinosaurs," says Czerkas.

respected paleontologist at Yale University's Peabody Museum of Natural History, proposed that birds descended from theropods, many scientists viewed him as a radical. But the clear impressions of feathers on the Liaoning fossils lengthen the list of feathered theropods, and we can now say that birds are theropods just as confidently as we say that humans are mammals. Everything from lunch boxes to museum exhibits will change to reflect this revelation.

A simple paper sign with "Chris" scribbled on it, tacked to a weathered post, is my signal to turn into the Czerkas ranch in southeastern Utah. It's May 1999, and I'm about to meet up with one of the Chinese specimens that, right now, only a few people know about. Stephen and Sylvia Czerkas, directors of the Dinosaur Museum in Blanding, found it early this year at a gem and mineral show. Immediately recognizing its scientific value, they found benefactors and purchased it quietly, planning to give it a home in the museum. "We wanted to make sure it didn't end up on a mantel in someone's private collection," says Sylvia.

RESEARCH PROJECT

Supported in part by your Society

According to Chinese officials any fossils leaving China—including countless bird specimens and dinosaur eggs that have appeared on the international market—are illegal exports. So, after completing their study of the fossil, the Czerkases now plan to return it to China.

Stephen draws me into a back room to view the animal he will later name *Archaeoraptor liaoningensis.* I've seen feathered dinosaur specimens, but what Stephen shows me takes my breath away. Its long arms and small body scream "Bird!" Its long, stiff tail—which under magnification erupts into a series of tiny support rods paralleling the vertebrae—screams "Dinosaur!"

Surrounding the bones, which suggest that the animal is a dromaeosaur-like primitive bird, are the remains of feathers. Some are similar to the hairlike protofeathers of the flightless *Sinosauropteryx* found in 1996.* But others look long and broad, seductively suggesting flight feathers. "It's a missing link," Stephen says. "We can't prove that it flew, but even aside from its feathers, its anatomy—long arms, birdlike shoulders, hands, and wrists—doesn't make sense unless it did."

Three weeks earlier I had viewed the other two Liaoning fossils at the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing. The first, a dromaeosaur, was an eagle-size creature named *Sinornithosaurus millenii,* "Chinese bird-reptile of the millennium." It was exquisitely fierce looking, with barracuda-like teeth and long curved claws. It reminded me of John Ostrom's description of dromaeosaurs: "bizarre killing machines."

Paleontologist Xu Xing showed how the bones of *Sinornithosaurus millenii*'s shoulder girdle—the scapula, coracoid, and furcula—are more like those of a bird than those of a dinosaur. Critical for flight, these bones join at the glenoid fossa, a cup-shaped area that determines the degree to which a bird can raise its wings above its shoulder to flap. "If you saw just this shoulder girdle, you would think it was *Archaeopteryx,* the earliest bird," he said.

In a room across a dimly lit hall Xu

*See "Dinosaurs Take Wing," by Jennifer Ackerman, in the July 1998 National Geographic.

FROM GROUND TO AIR

Fast, bipedal meat-eaters called theropods have four new species: *Sinornithosaurus millenii, Beipiaosaurus inexpectus, Archaeoraptor liaoningensis,* and an unnamed oviraptorosaur. Beginning with the primitive *Sinosauropteryx,* all theropods, including *T. rex,* may have had feathers, one of the adaptations that led to flight in *Archaeopteryx* and perhaps *Archaeoraptor.*

Former Senior Assistant Editor Lou Mazzatenta photographed evidence of the earliest life on Earth for the magazine's March and April 1998 issues.

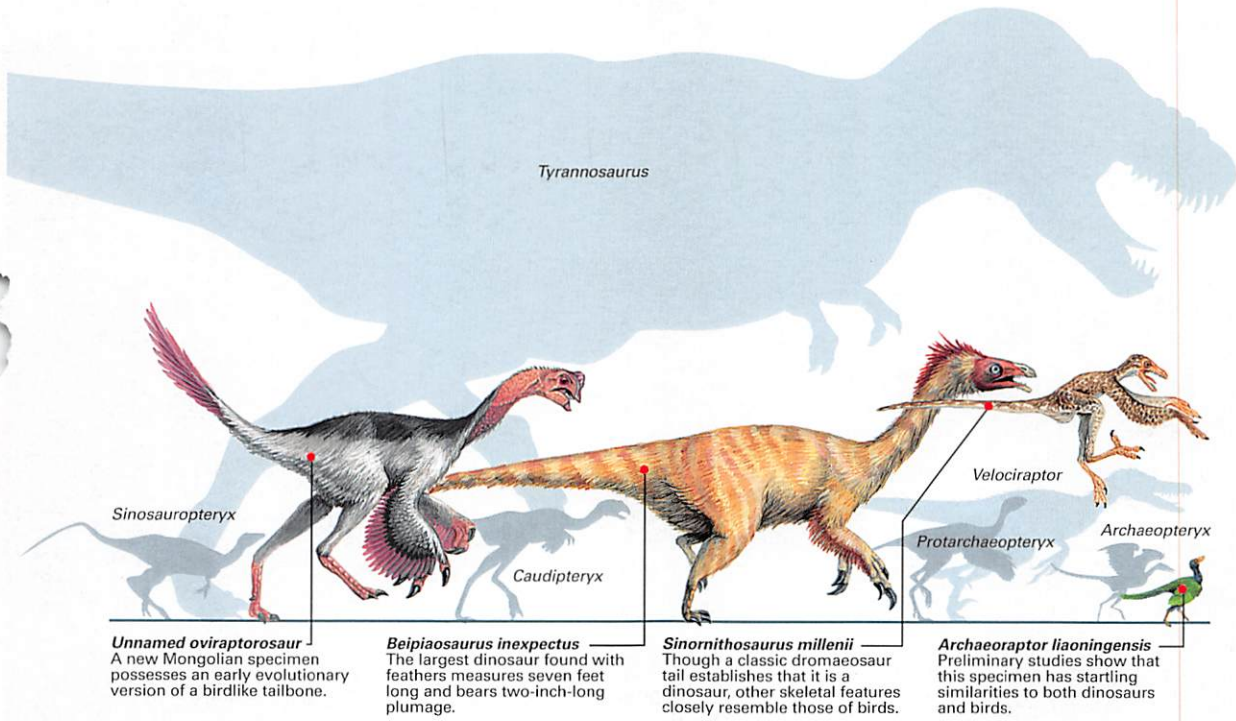
showed me the other feathered theropod, *Beipiaosaurus inexpectus,* one of only a few therizinosaur specimens known. Farmers discovered the gray bones near the town of Beipiao and discarded them, believing they had no commercial value. Xu and his colleagues chanced upon scraps of the fossil and salvaged the remaining pieces from the site.

The young scientist handed me a flat piece of rock about the size of my hand. It bore pink comblike impressions that suggested stiff, narrow feathers. "These filaments might have had hollow cores," he said. This is a key feature, since hollow, hairlike structures characterize protofeathers—evolutionary intermediates between reptilian skin and feathers.

At seven feet long, *Beipiaosaurus* is the largest dinosaur yet found with feathers. But why did it have them, since neither this therizinosaur nor its ancestors ever flew? One explanation is that their feathers did not evolve for flight but for insulation—which gives rise to another question: Were dinosaurs warm-blooded?

Biologist Mary Schweitzer of Montana State University, who has studied the small fibrous structures on a birdlike creature from Mongolia named *Shuvuuia deserti,* is helping to answer that question. Her tests show that the fibers are similar, chemically and structurally, to modern feathers. "The only animals living today with body coverings of hair or feathers

Obsolete model: Baby *T. rex* in 1997's *Lost World: Jurassic Park* probably would have feathers if the movie were made today.




HEAD
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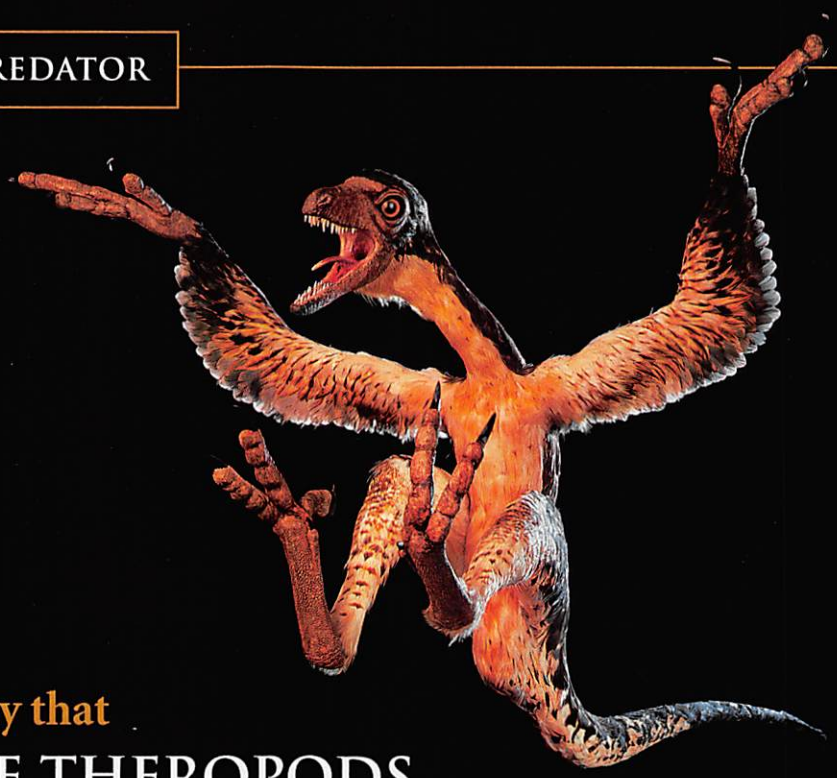
FEATHERED PREDATOR



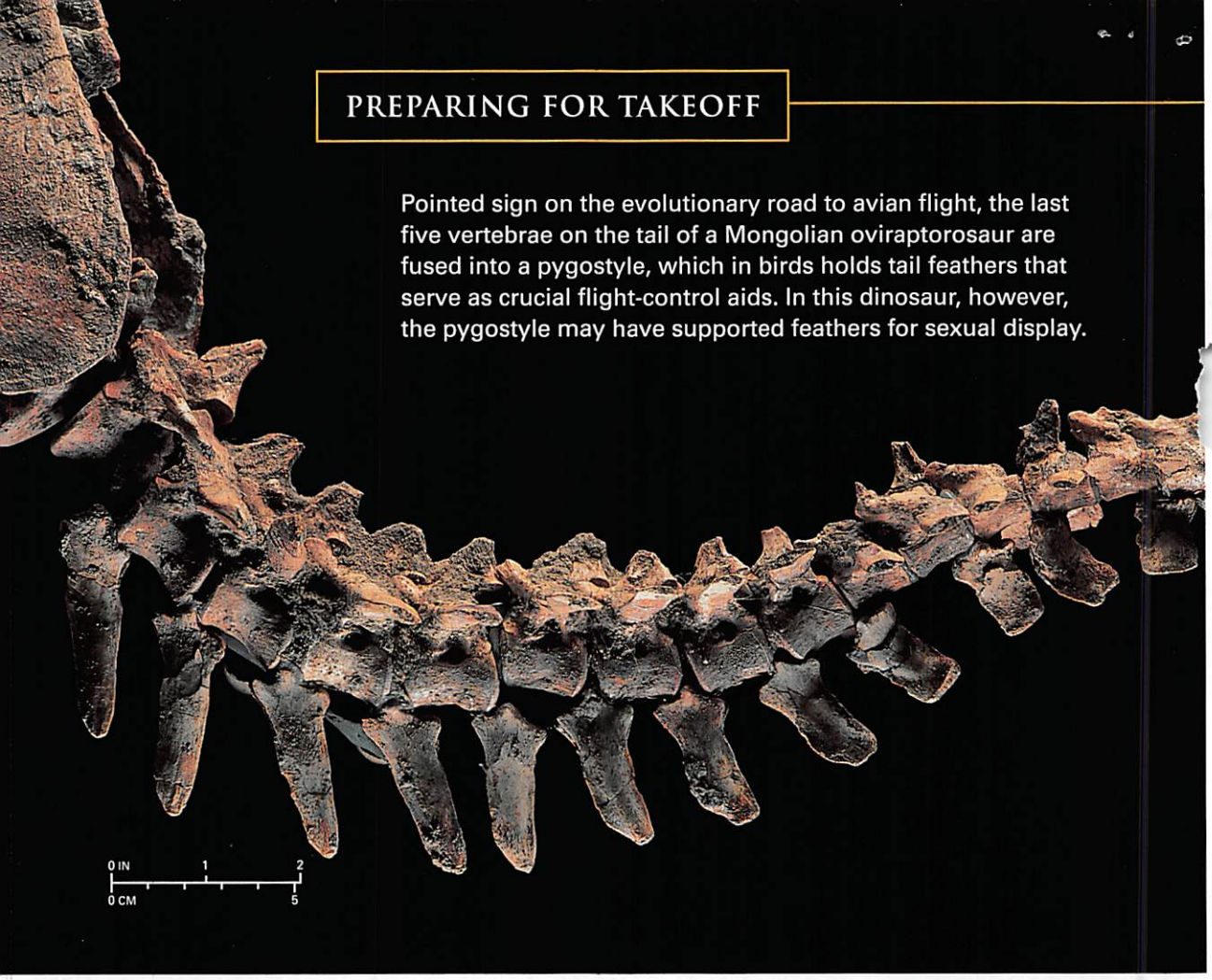
We can now say that
BIRDS ARE THEROPODS
just as confidently as we say that humans are mammals.

Halo of feathers radiates from the fossilized bones of *Sinornithosaurus millenii* (left), which lived more than 120 million years ago. A sculptor's depiction (above) shows it pursuing prey; it probably fed on lizards and small mammals. Although the creature was apparently covered with downy feathers, it could leap but not fly. However, its boomerang-shaped furcula, or wishbone (far right), resembles that of the primitive bird *Archaeopteryx,* according to paleontologist Xu Xing. Resting near two claws, the tail vertebrae anchor bundles of slim bony rods (below) that stiffened the tail to aid maneuverability. This feature identifies *Sinornithosaurus* as a dromaeosaur, one of the most effective predators of its day. The fossil also supports the concept that early feathers evolved for insulation or display rather than flight and adds new weight to the idea that these dinosaurs were warm-blooded.

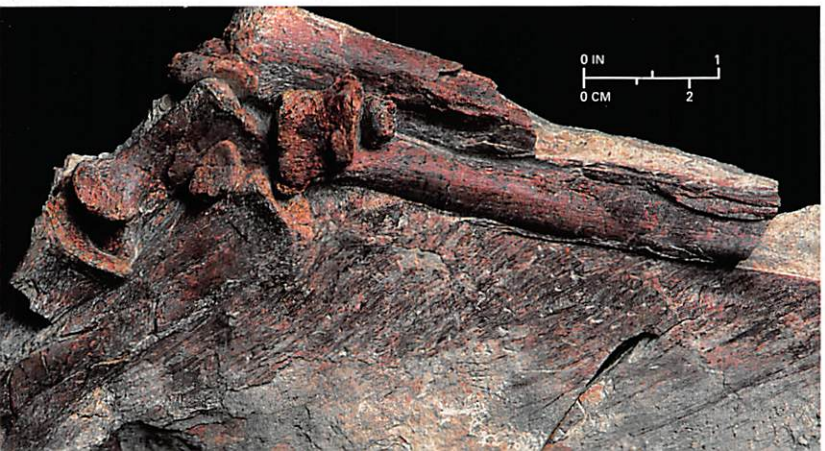
MODEL BY BRIAN COOLEY

PREPARING FOR TAKEOFF

Pointed sign on the evolutionary road to avian flight, the last five vertebrae on the tail of a Mongolian oviraptorosaur are fused into a pygostyle, which in birds holds tail feathers that serve as crucial flight-control aids. In this dinosaur, however, the pygostyle may have supported feathers for sexual display.



Largest feathered dinosaur yet found, *Beipiaosaurus* was a therizinosaur, a long-necked, long-clawed theropod. Its wispy feathers, which extended two inches from the forearm (below), were used not for flight but probably for insulation. "I think therizinosaurs 'chose' a slower lifestyle, evolving from meat-eaters to plant-eaters," says Xu Xing, who is studying the fossil at China's Institute of Vertebrate Paleontology and Paleoanthropology in Beijing.



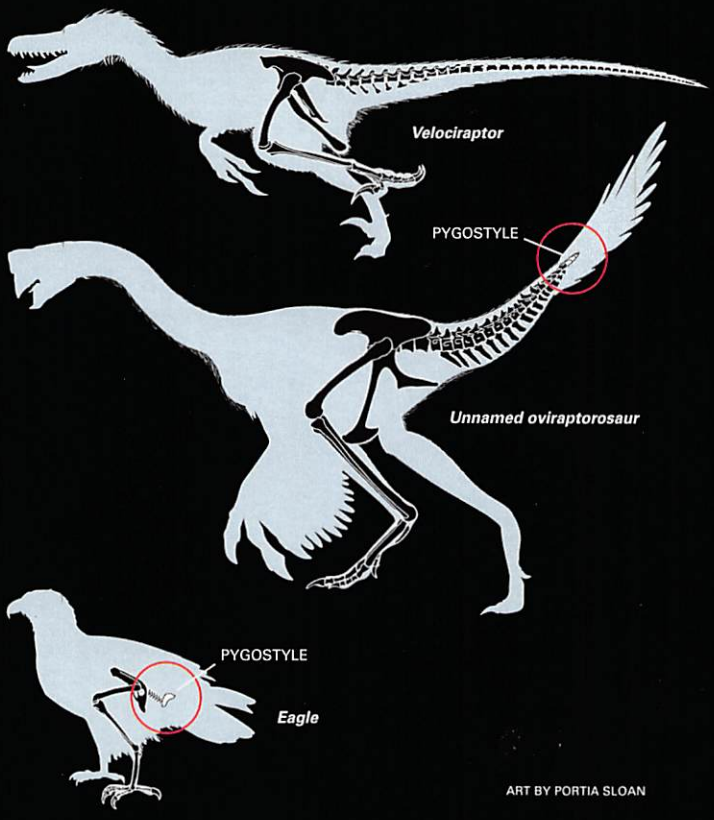
have the high metabolic rates of warm-blooded creatures," she says. "It seems reasonable to assume that this was true in the past as well. Dinosaurs that possessed body coverings were probably either warm-blooded or had metabolic rates significantly higher than those of modern cold-blooded animals."

But the larger an animal becomes, the less likely it is to need a coat of hair or feathers for insulation, since large bodies generate more heat. The last thing an adult *T. rex* in a subtropical Cretaceous world would have needed was a warm coat. "If adult *T. rex* had feathers, it was probably only for display," says Philip Currie, theropod expert and curator of dinosaurs at the Royal Tyrrell Museum in Drumheller, Alberta.

But what about *T. rex* juveniles? "Baby animals have less

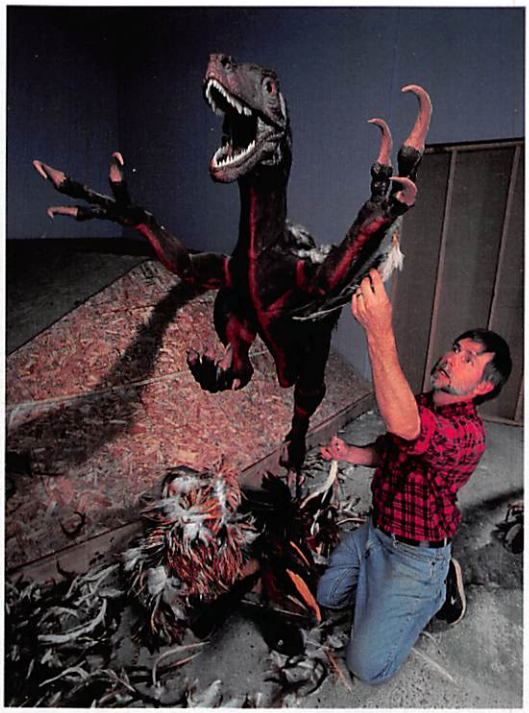
Acting as a counterbalance, the tail of *Velociraptor* (top right) is composed of many vertebrae. In an oviraptorosaur (center) the tail has fewer

vertebrae and ends with an incipient version of the pygostyle. As birds evolved, the tail drastically shortened, as in an eagle (bottom). The pygostyle's tail feathers serve the bird in flight maneuvers and in displays to attract mates and intimidate rivals.



ART BY PORTIA SLOAN

Mounting fossil evidence that feathers were common among theropods led Stephen Czerkas of the Dinosaur Museum in Blanding, Utah, to add plumage to an earlier model of a dromaeosaur called *Deinonychus* (right). Depictions of many theropod species may change as museums rethink the appearance of these precursors of modern birds.



control of their body temperature than adults," says Currie. "*T. rex* hatchlings needed a way to stay warm. What would be more logical than insulating feathers?"

A photograph of a bird in flight freezes its wings in a pose—a mere suggestion of the complicated process of flight. In a similar way the new Liaoning fossils create a snapshot of reptilian skin evolving into feathers. Perhaps someday a new discovery will capture the moment when a flying dinosaur became a bird. □

For a 3-D view of a feathered dinosaur, go to *www.nationalgeographic.com/dinorama.*

AFTER THE DELUGE

CENTRAL AMERICA'S STORM OF THE CENTURY

BY A. R. WILLIAMS
NATIONAL GEOGRAPHIC SENIOR STAFF

PHOTOGRAPHS BY VINCENT J. MUSI

Mud and debris piled high by flooding form one of the many obstacles that residents of Tegucigalpa, the capital of Honduras, must surmount after Hurricane Mitch devastated the region a year ago. Areas hardest hit are still struggling to recover.